

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT I, YASUTOSHI HIRANO, a citizen of Japan residing at Osaka, Japan have invented certain new and useful improvements in

DIGITAL SIGNAL PROCESSOR AND MODEM USING THE SAME

of which the following is a specification:-

09955885-091901

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a digital signal processor and a modem using the digital signal processor, and more particularly, to a digital signal processor having an external ROM storing a program, forwarding a program to be executed to an internal program RAM if necessary, and executing an instruction stored in the internal program RAM, and a modem using the digital signal processor.

2. Description of the Related Art

Recent progress of digital signal processor (DSP) has expanded the scale of a processable digital signal process. The scale of a program RAM provided in the DSP is limited due to cost problems and the like.

Therefore, for execution of a program that is beyond the capacity of the internal program RAM of a small scale, an external ROM having an area for storing programs is used together with the DSP. The program is read from the external ROM and is transferred to the internal program RAM of the DSP as necessary. For instance, Japanese Laid-Open Patent Application No. 9-31184 discloses a signal processing

09955885-091901

apparatus using a DSP as described above. The signal processing device includes a plurality of DSPs and a ROM that is provided outside of the DSPs and stores programs. Programs are transferred from the ROM to

5 internal program RAMs of the DSPs at the time of starting up the apparatus. The DSPs execute the programs stored in the internal program RAMs.

Another signal processing apparatus is disclosed in Japanese Laid-Open Patent Application No. 2000-40028.

10 The apparatus has external ROM storing programs, a DP-RAM and a CPU, these components being provided outside of a DSP. The CPU forwards a program needed to the DP-RAM from the external ROM. Then, a reset signal that has been applied to the DSP is removed.

15 This results in activating the DSP, which fetches the program from the DP-RAM and stores it in an internal program RAM. Then, the DSP starts to execute the program in the internal program RAM. However,

Japanese Laid-Open Patent Application No. 9-31184 and

20 the Japanese Laid-Open Patent Application No. 2000-40028 have the following disadvantage. When the program in the program RAM built in the DSP is replaced, the re-set signal is asserted to the DSP.

After the program is replaced by another program, the

25 DSP is initialized. For a DSP having an I/O port, it

09955885-091901

is therefore necessary to reset the I/O port for each replacement. This degrades the performance of the DSP. In the meantime, recent progress of the DSP has made it possible to implement data

5 modulation/demodulation of a modem by DSP and to improve the transmission rate. Nowadays, an increased number of modulation/demodulation formula is available. However, it is difficult in terms of cost to store all programs respectively describing
10 the modulation/demodulation formula in the internal program RAM in the DSP.

In addition, new recommendations about the modem are added with a short cycle. In order to follow the new recommendations, it is necessary to
15 replace the DSP by a new DSP in which programs corresponding to the new recommendations are described. This is disadvantageous to manufacturers and customers. Taking into account the above, a recent modem is equipped with a DSP having a small-
20 scale program RAM and a rewritable ROM provided outside of the DSP. A program stored in the ROM is transferred to the program RAM in the DSP as necessary. The use of the external ROM easily copes with addition of recommendations by updating.

25 Japanese Laid-Open Patent Application No. 6-164655

09955835-091901

discloses a modem which uses a DSP having an external ROM storing a program, forwarding a program to be executed from the ROM to an internal program RAM, and executing instructions stored in the internal program RAM.

However, the program for data modulation/demodulation should be replaced promptly in the modem with the DSP because the replacement is carried out during communication.

Conventionally, a reset signal is asserted to the DSP for replacement of program, and is removed to activate the DSP. Just after activation following the removal of the reset signal, an internal parameter in the DSP and a parameter in an analog front end (AFE) have been initialized by the reset signal. Thus, it is necessary to reset the above parameters. Accordingly, it takes a long time to start the modulation/demodulation program and communication may be broken down in practice.

Furthermore, even for the same data modulation/demodulation formula, parameters with respect to the receiving and transmission are changed based on the change of a carrier frequency and a modulation rate although the algorithm is unchanged.

In the above state, it is necessary to change all

09955885-091901

Sub
A1

A)

programs in compliance with the change of the carrier frequency and the modulation rate, because the internal program RAM is initialized by the reset signal and it is impossible to change a part of the program. Otherwise, it is necessary to load every parameter to the program RAM with the same modulation form.

However, there is a problem that it takes a long time to change all programs. There is another program that loading of every parameter needs a large scale of the internal program RAM, which increases the cost.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful digital signal processor and a modem using the digital signal processor in which the problems described above are eliminated.

Another and more specific object of the present invention is to provide a signal processing apparatus in which programs stored in a external memory part can be forwarded to an internal memory part without resetting a DSP, by controlling outputting of a clock signal.

09955885-091901

The above objects of the present invention are achieved by a signal processing apparatus including a digital signal processor including an internal memory part storing a program to be
5 executed; an external memory part storing programs executable in the digital signal processor; a clock signal generating part generating a clock signal and outputting the clock signal to the digital signal processor; and a clock signal control part
10 controlling outputting of the clock signal to the digital signal processor so that the programs stored in the external memory part can be forwarded to the internal memory part. More particularly, the clock signal control part forwards the programs read from
15 the external memory part to the internal memory after stopping outputting the clock signal to the digital signal processor. Accordingly, the programs stored in the external memory part can be forwarded to the internal memory part without resetting the DSP in
20 case of that it is necessary to replace the program during that the DSP is working. It is possible to execute a large scale program by using small scale internal memory whose memory scale is small without falling a level of performance of the DSP. Besides,
25 it is possible to save consumption electricity

09955885-091901

because it is stopped to supply a clock signal to the DSP during that the program in the internal memory is replaced.

It is also an object of the present
5 invention to provide a signal processing apparatus,
wherein the clock signal control part controls
outputting of the clock signal to the digital signal
processor in compliance with a request from the
digital signal processor. Accordingly, it is
10 possible to replace the internal program memory
without initializing of the DSP in compliance with a
request from the DSP.

Besides, it is an object to provide a signal
processing apparatus, wherein the clock signal
15 control part controls outputting of the clock signal
to the digital signal processor in compliance with a
request from an outside of the signal processing
apparatus. Accordingly, it is possible to replace
the internal program memory without a request from an
20 outside of the signal processing apparatus.
Therefore, it is possible to correspond a primary
factor of replacing a program detected by the outside
host processor, so that flexible system design can be
done.

25 Furthermore, it is an object to provide a

09955885-091901

signal processing apparatus, wherein the clock signal control part includes a forward circuit for forwarding a desired part of the programs read from the external memory part to the internal memory.

- 5 Accordingly, it is possible to replace the program in a short period of time, so that it is possible to control to replace the program closely.

- Still another object of the present invention is to provide a modem for
- 10 modulating/demodulating a communication data by using a signal processing apparatus including a digital signal processor including an internal memory part storing a program to be executed; an external memory part storing programs executable in the digital
- 15 signal processor; a clock signal generating part for generating a clock signal and outputting the clock signal to the digital signal processor to the digital signal processor; and a clock signal control part controlling outputting of the clock signal to the
- 20 digital signal processor so that the programs stored in the external memory part can be forwarded to the internal memory part. More particularly, the clock signal control part forwards the programs read from the external memory part to the internal memory after
- 25 stopping outputting the clock signal to the digital

09955885-091901

signal processor.

Accordingly, it is not necessary to reset an inside parameters of the DSP and parameters of AFE after the program in the internal memory of the DSP, 5 so that it is possible to execute the modulation/demodulation program immediately. Therefore, as compared with the modem in prior arts, it is possible to reduce the possibility of the cutting of the communication.

10 It is also an object to provide a modem, wherein the clock signal control part controls outputting of the clock signal to the digital signal processor in compliance with a request from the digital signal processor. Accordingly, it is 15 possible to replace the internal program memory without initializing of the DSP in compliance with a request from the DSP.

Besides, it is an object to provide a modem, wherein said clock signal control part controls 20 outputting of said clock signal to said digital signal processor in compliance with a request from an outside of said signal processing apparatus. Accordingly, it is possible to replace the internal memory partially in compliance with a request from an 25 outside of said signal processing apparatus, so that

09955885-091901

it is possible to replace the program in a short period of time and it is possible to control to replace the program closely. Because the control is implemented by the host processor outside of the DSP
5 signal processing apparatus, it is possible to correspond a primary factor of replacing a program detected by the host processor, so that flexible system design can be done.

Sub A2
10 It is also object to provide a modem, wherein the clock signal control part includes a forward circuit for forwarding a desired part of the programs read from the external memory part to the internal memory. Therefore, in case of that parameters only related to transmitting and receiving
15 are different in a state where a carrier frequency and a modulation rate are different even if modular formulation is same, it is possible to keep the modulation formulation program and change only parameters, because it is possible to change not all
20 but a part of the modulation/demodulation program.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an example of a DSP signal processing apparatus according to an embodiment of the present invention;

5 FIG. 2 is a flowchart showing an example of an action of the DSP signal processing apparatus of Fig. 1;

FIG. 3 is a flowchart showing another example of an action of the DSP signal processing apparatus of Fig. 1; and

FIG. 4 is a block diagram showing an example of a modem using the DSP signal processing apparatus of Fig. 1.

15 DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of a DSP signal processing apparatus according to an embodiment of the present invention.

Sub
A3
20 Referring to Fig. 1, a DSP signal processing apparatus 1 includes a DSP 2, an external ROM 4, and a forward circuit 5. The DSP 2 has an internal program RAM 3 in which a program to be executed is stored. The external ROM 4 stores all executable programs by the DSP 2. The forwarding circuit 5
25 forwards a desired program from the external ROM 4 to

09955885-091901
T06T60-5885560

A3

the internal program RAM 3. Besides, the DSP signal processing apparatus 1 includes a clock generating circuit 6 and a clock control circuit 7. The clock generating circuit 6 generates a clock signal CLK, which is supplied to the DSP 2 and the forwarding circuit 5. The clock control circuit 7 controls outputting of the clock signal CLK generated by the clock generating circuit 6 to the DSP 2. The forwarding circuit 5 and the clock control circuit 7 compose a clock signal control part.

The external ROM 4 and the forward circuit 5 are connected by a forward data bus 11. The forward circuit 5 and the internal program RAM 3 are connected by a forward data bus 12. Furthermore, the forward circuit 5 outputs a control signal Sa to the external ROM 4, a control signal Sb to the internal program RAM 3, and an output signal Sc to the clock control circuit 7.

Besides, a request signal Sd to replace the program stored in internal program RAM 3 and an internal state signal Se showing an access state to the internal program RAM 3 are respectively input from the DSP 2 to the forward circuit 5.

The clock generating circuit 6 outputs a generated signal to the forward circuit 5 and to the

09955885-091901
T06T60-58855660

DSP 2 through the clock control circuit 7. Besides,
a request signal Sf to replace the program stored in
internal program RAM 3 may be input from an external
host processor 15 to the forward circuit 5. In the
5 above state, the clock signal CLK is input from the
clock generating circuit 6 to the host processor 15.

The DSP 2 works on the basis of the
inputted clock signal CLK, and stops working until
the clock signal CLK inputs if the clock signal CLK
10 is not inputted.

Under the above structure, actions of
respective parts of the DSP signal processing
apparatus 1 in a case where the request signal Sd to
replace the program is input from DSP 2 to the
15 forward circuit 5 will be explained as follows.

The DSP 2 outputs the request signal Sd to
replace the program stored in internal program RAM 3
to the forward circuit 5. The forward circuit 5
detects a cycle in which the DSP 2 does not access
20 the internal program ROM 3, namely in which the DSP 2
opens an internal program bus by a DSP inter state
signal Se and outputs, to the clock control circuit 7,
the control signal Sc requesting that the clock
control circuit 7 does not output the clock signal
25 CLK to the DSP 2.

09955885-091901

The clock control circuit 7 stops outputting the clock signal CLK to the DSP 2 on the basis of the control signal Sc requesting that the clock signal CLK inputted from the forward circuit 5 stops being
5 output to the DSP 2. After that, the forward circuit 5 reads out desired program data from the external ROM 4 by using the control signal Sa and the forward data bus 11, and forwards the program data read out
10 Sb and the forward data bus 12.

The forward circuit 5 recognizes the place of the external ROM 4 from which the program is to be forwarded is read and the location and size of the internal program RAM 3 to which the program is to be
15 forwarded, because a memory space, a memory size and the like with respect to the data to be forwarded are set in advance.

After finishing forwarding the program to the internal program RAM 3, the forward circuit 5
20 outputs, to the clock control circuit 7, the control signal Sc requesting the clock control circuit 7 supplies the clock signal CLK to the DSP 2. The clock control circuit 7 restarts supplying the clock signal CLK to the DSP 2. The DSP 2 starts working by
25 the replaced program stored in the internal program

09955885-091901

RAM 3, on the basis of that the clock signal CLK is input to the DSP 2. Thus, it is finished to replace the program stored in the internal program RAM 3.

FIG. 2 is a flowchart showing an action of the changing the program in internal program RAM 3 of the DSP signal processing apparatus 1 shown in Fig. 1. Referring to Fig. 2, the actions of the respective parts of the DSP signal processing apparatus 1 in a case where the program in the internal program RAM 3 is replaced will be explained as follows.

Referring to Fig. 2, first of all, in step 1, the DSP 2 implements a setup process of the forward circuit 5, an address of external ROM 4 starting reading out the program data, an address of the internal program RAM 3 writing the program in, and the numbers of forwarding the data, with respect to the register in the forward circuit 5 and the like for instance.

Next, the DSP 2 outputs the request signal Sd to replace the program to the forward circuit 5 in step 2. In step 3, the forward circuit 5 investigates by the inside state signal Se whether or not it is possible to forward the program data to the internal program RAM 3, namely whether or not the DSP 2 is in a cycle in which the DSP 2 does not access to

09955885-091901
T06T60-58855660

the internal program RAM 3. If YES to the step 3, that is, it is possible to forward the program data to the internal program RAM 3, the forward circuit 5 outputs the control signal Sc requesting the clock control circuit 7 stop outputting the clock signal CLK to the DSP 2 in step 4. If NO to the step 3, that is, it is not possible to forward the program data to the internal program RAM 3, the process of the step 3 continues implementing until it is possible to forward the program data to the internal program RAM 3.

Next, in step 5, the clock control circuit 7 stops outputting the clock signal CLK to the DSP 2, so that the DSP 2 stops working. In step 6, the forward circuit 5 reads out the desired program data from the external ROM 4 and writes it in the internal program RAM 3. And then, in step 7, the forward circuit 5 does increment of the address of the external ROM 4 reading out the program data, the address of the internal program RAM 3 writing the program data in, and the numbers of the program data which is finished forwarding, respectively, which are set up in the register in the forward circuit 5.

Next, in step 8, the forward circuit 5 confirms the number of the program data which is

09955885-091901

forwarded to the internal program RAM 3 and decides whether or not the data forwarding is finished, namely, whether or not the number of the program data which is forwarded is the predetermined numbers of
5 the forwarding of program data.

If NO to the step 8, that is the data is not finished forwarding, the process goes back to the step 6. If YES to the step 8, that is the data is finished forwarding, the forward circuit 5 outputs
10 the control signal Sc requesting that the clock control circuit 7 supplies the clock signal CLK to the DSP 2 in step 9. In step 10, the clock control circuit 7 restarts supplying the clock signal CLK to the DSP 2. The DSP 2 restart working by the program
15 in the replaced internal program RAM 3 in step 11 and the present flow goes to end.

The case where the request signal Sd to replace the program is output from the DSP 2 to the forward circuit 5, as an example, is explained in the
20 above. The case where the request signal Sf to replace the program is output from host processor 15 to the forward circuit 5, as an example, will be explained with a flowchart of Fig. 3 as follows. The same flow as one in Fig. 2 is mentioned with the same
25 mark in Fig. 3 and the explanation with respect to

09955885-091901

the same flow will be omitted and only different points from the flow in Fig. 2 will be explained. As compared with the flow in Fig. 2, the step 1 of Fig. 2 is exchanged to a step 21 in Fig 3 and the step 2 of Fig. 2 is exchanged to a step 22 in Fig 3.

Referring to Fig. 3, first of all, in step 21, the host processor 15 implements a setting up process of the forward circuit 5, an address of external ROM 4 starting reading out the program data, an address of internal program RAM 3 writing the program in, and the number of forwarding the data, with respect to the register in the forward circuit 5 and the like for instance. Next, the host processor 15 outputs the request signal Sf to replace the program to the forward circuit 5 in step 22. After that, the processes from the step 3 to the step 11 are implemented.

Thus, according to the present embodiment of the DSP signal processing apparatus 1, when the program stored in the internal program RAM 3 in the DSP 2 is replaced, the forward circuit 5 stops that the clock control circuit 7 supplies the clock signal CLK to the DSP 2, reads out the desired program stored in the external ROM 4, and makes the internal program RAM 3 renew and store the program. As finish

0955885-091901

of the forwarding, the clock control circuit 7
restarts supplying the clock signal CLK to the DSP 2.
Accordingly, if a state in which it is necessary that
the program in the internal program RAM is replaced
5 during that the DSP works happens, it is possible to
replace the program in the internal program RAM
without resetting the DSP, so that it is possible to
carry out large scale program by the internal program
RAM whose memory scale is small without falling the
10 performance of the DSP. Furthermore, it is possible
to reduce consumption of electricity because it is
stopped to supply the clock signal to the DSP during
that the change of the program in the internal
program RAM.

15 FIG. 4 is a block diagram showing an example
of a modem using the DSP signal processing apparatus
1 of Fig. 1. The same parts as ones in Fig. 1 are
mentioned with the same mark in Fig. 1 and the
explanation with respect to the same parts as ones in
20 Fig. 1 will be omitted.

Referring to Fig. 4, a modem 21 comprises
the DSP signal processing apparatus 1, the host
processor 15, and an analog front end (hereinafter
"AFE") 22 converting an analog signal in a
25 communication circuit such as a public circuit system

09955885-091901

and the like into a digital signal

The DSP 2 is connected to the communication circuit such as the public circuit system and the like through the AFE 22. The host processor 15 is connected a data terminal equipment (hereinafter "DTE") 25 comprising an information process apparatus such as a personal computer and the like. In case of that the DTE 25 is the personal computer, the host processor 15 is connected to the DTE 25 by an RS232C for instance. The DSP 2 implements data modulation/demodulation in the modem 21. The host processor 15 mainly transfers data with the DTE 25, controls the whole of the modem 21, and like that. The host processor 15 is also connected with the forward circuit 5 and the DSP 2.

In case of that the data from the DTE 25 is transmitted to the communication circuit, the data outputted from the DTE 25 to the host processor 15 is converted in accordance with a protocol provided by the host processor 15 and is outputted to the DSP 2 as modulation data. The DSP 2 modulates the inputted data to the DSP 2 according to the program stored in the internal program RAM 3 and converts the input data to the DSP 2 to a digital signal in a telephone system area. The digital signal converted by DSP 2

09955885-091901

is converted to an analog signal by the AFE 22 and then transmitted to the communication circuit such as a public circuit system.

In case of that the data is received from
5 the communication circuit such as a public circuit system to the DSP 2, the analog signal received from the communication circuit such as a public circuit system is converted to the digital signal by AFE 22 and input to the DSP 2. The DSP 2 demodulates the
10 inputted data to the DSP 2 according to the program stored in the internal program RAM 3 and outputs to the host processor 15. The host processor 15 converts the input demodulation data to the receiving data in accordance with a protocol provided by the
15 host processor 15 and outputs the DTE 25. The DSP 2 calculates the modulation/demodulation according to the program stored in the internal program RAM 3. The calculation for the modulation/demodulation depends on the advice to be applied. The explanation
20 with respect to the action to replace the program in the internal program RAM 3 in the DSP signal processing apparatus 1 will be omitted because the action has already been explained in the Figs 1 to 3.

Thus, it is not necessary to reset an inside
25 parameter of the DSP 2 and the parameter of the AFE

09055885-091901

Sub
194

A4

22 and the like after the program in the internal
program RAM 3 is replaced, so that the
modulation/demodulation program can be carried out
immediately, by using the DSP signal processing
5 apparatus 1 according to the above embodiment to the
modem. Therefore, as compared with the modem of
prior arts, it is possible to reduce a possibility in
that the communication is cut in case of that the
program is replaced. Besides, in case of that
10 parameters only related to transmitting and receiving
are different in a state where a carrier frequency and
a modulation rate are different even if modular
formulation is same, it is possible to keep the
modulation formulation program and change only
15 parameters, because it is possible to change not all
but a part of the modulation/demodulation program.

The present invention is not limited to
these embodiments, but various and modifications may
be made without departing from the scope of the
20 present invention.

0995885-091901